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Earthworms in Relation to Agriculture

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Ever since Darwin studied the habits of earthworms three centuries ago, evidence has been accumulating that these lowly creatures have significant effects on soils. Others have observed that the presence of earthworms is usually an indication of good tilth and fertility. In certain cases, claims have been made of remarkable improvements in soils solely from earthworm activity. This and the appearance of popular articles in the press has created widespread interest in earthworms during recent years. As a result the U. S. Department of Agriculture receives many inquiries about them. Some want to know how to increase earthworms in fields and gardens. Others want to know how to destroy them in greenhouse soils and on lawns.

Information has been collected from many sources to answer these and other questions. A gist of it is given in the following pages.

Occurrence of Earthworms

Earthworms are distributed through all sections of the country where soil conditions and climate are suited to their survival. They are especially plentiful in the richer soils, but they are present also in ordinary farmland. The common varieties have been introduced from Europe, probably in soil brought along with plants. By now, however, their distribution is largely a reflection of natural variations in climate and soil from place to place. They are more prevalent in the humid sections of the East than in the arid West, but even in desert regions they sometimes occur along water courses and in irrigated land.

Where reasonable moisture conditions prevail earthworm occurrence is determined primarily by soil variations. They are more abundant in soils derived from limestone, or otherwise rich in plant nutrients and organic residues, then they are in infertile and acid soils. They are found more frequently in silt and clay loams than they are in sandy soils.

Some common methods of growing crops tend to destroy earthworm populations. When soil is left bare over winter, when it is allowed to bake under a hot sun and when it is compacted with heavy machinery, the earthworm population suffers. On the other hand, a soil conservation program that adds organic matter to the soil and improves it for crops usually keeps it in good condition for earthworms.

Maintenance of earthworms under field conditions requires soil management that will meet the life requirements of the species. Earthworms, like other animals, thrive only when their requirements for food, water and shelter are met.

The number of earthworms in your soil can be determined without difficulty. The examination can be made at any season of the year, although easiest during the cool humid periods of spring and fall when the earthworms work close to the surface of the soil. Dig out a square of earth one foot across to a depth of about 7 inches. Count all the earthworms you can find in this sample. Include both mature and young ones. If the sample contains not less than 10 or 12 earthworms the population is large enough to be effective in modifying the physical condition of the soil. This number of earthworms per square foot equals a half million earthworms per acre.

Earthworms are known by other names, as angleworms, dew worms, gardenworms, groundworms, night crawlers, rainworms and redworms. All of these names refer to the same class of worms, but are sometimes used to denote a particular species.

Kinds of Worms in Agricultural Soil

Of the more than 3,000 species of earthworms in the world, only a few are important in agricultural soils of the United States.

The night crawler, Lumbricus terrestris, is the largest of our earthworms. It is more common in the northern States. Heavy fertilization seems to favor its development in meadows and lawns.

Helodrilus caliginosus, with its variant form, trapezoides, is known as the common field worm. It occurs throughout the humid area of the country. It is more common than the night crawler, particularly in the southern States. In the same locality, this species may prevail where the fertility level is too low for the night crawler.

On soils of extremely low fertility, neither of these species does well. In rundown bromesedge fields around Washington, D. C., for example, the main kind is the small slim worm, Diplocardia verrucosa. It has no English name. Its holes and casts are so small that it has only a minor effect on soil properties.

Another species found in agricultural soils is the green worm, Helodrilus chloroticus. It is a rather short but stout greenish worm. Only because of its prevalence is this worm deserving of comment; it is quite inactive. Often it is found curled up in a semi-dormant condition while other worms are active.

Two other kinds worth mentioning are especially common in compost piles. One is the so-called manure worm, Helodrilus foetidus. It is known also as the brandling or red wriggler, the latter because of its squirming reactions when handled. This species can be told by the transverse rings of yellow and maroon which alternate the length of its body. The other is the stouter Lumbricus rubellus. It is a deep maroon color and does not have the yellow bands of the manure worm. Both these earthworms invade refuse, although the former is more prevalent in manure piles. Neither occurs commonly in agricultural land although the latter may be found where moderate amounts of refuse are added to the soil.

There has been considerable popular emphasis on introducing "hybrid" or specially-bred earthworms for soil improvement. To the best of our kn wledge there are no hybrid earthworms. Neither do we know of any artificially developed strains with special soil-building abilities not found among the various kinds of natural earthworms. The earthworm that is ordinarily sold as "hybrid" or "domesticated" appears to be identical with the species Helodrilus foetidus.

What They Do For Soil

Unfortunately, there has been a great deal of misunderstanding about what earthworms do for the soil. Just as there are some individuals who stick to the old idea that earthworms are without any real importance in farm soil, there are others who proclaim the earthworm a cure-all for every soil trouble. Both these extreme attitudes are wrong. There are many conditions that affect the productivity of soil, and earthworms change only certain of these conditions.

Earthworm activity is not one of the basic requirements for plant growth. Rather, it comes into the category of factors which can be used to correct deficiencies in these basic requirements. Like many of the other corrective measures, earthworm activity is not indispensable; but in some cases it is difficult to find other practical means of doing those things which are normally done by the earthworms.

Effect on soil moisture

Soil that consists chiefly of coarse particles, such as sand, usually absorbs water readily. But most soil is not of this kind. Our principal kinds of agricultural soil have large contents of finer particles, such as silt and clay. Unless modified by secondary agencies, the particles pack together and become almost impervious to water. Much of the rain then runs off the surface instead of entering the soil. When soil gets into this condition, the crops suffer from drought even though the location may be one where there is adequate normal rainfall.

The intake of water by fine soil is dependent to a marked degree on the presence of extraneous channels. Earthworm holes are highly effective channels that form an interconnected web and allow rain water to penetrate quickly throughout the topsoil layer. The water finds its way between the soil particles only slowly, but runs down the earthworm holes quickly.

The activity of earthworms is just one of several factors that increase the water-absorbing ability of soil. Rarely does one find soil with a large earthworm population that does not take water fairly rapidly; but perforation of the soil by the roots of sod plants likewise promotes increased infiltration, as does any practice which adds organic matter and improves soil structure or tilth. The heavier textured soils with few earthworms usually take water slowly; however, there are exceptions where other factors besides earthworms are effective in keeping the soil open.

As might be expected, the number of earthworms in the soil follows rather closely the amount of runoff and erosion. Soil that does not erode retains its organic matter and this provides food for earthworms. Conversely, the more earthworms there are in the soil, the better the intake and the less the runoff. Water erosion cannot occur unless there is runoff.

Effect on aeration

Earthworms are an effective agent for loosening and aerating the soil. Their burrows make passageways for roots to grow in. They perforate the topsoil especially and gradually penetrate the subsoil, opening it for root growth and depositing organic matter. Equally important is the granulation of the soil which they bring about. This is done by their production of casts from the soil and organic debris that they eat. As the soil becomes granulated with casts, it gets looser and looser.

An approximate rule is that earthworms produce their own weight of casts per day. Transposed onto a field basis, and using data from a large number of examinations in the North Atlantic and North Central States, it appears that the average quantity of soil converted into casts amounts to about 700 pounds per acre for each day's activity. This rate of activity holds in the damp periods of the year only; for earthworms become dormant as the soil becomes dry.

Effect on nutrients

Earthworms affect the nutrient-supplying capacity of soil by taking organic debris from the surface and incorporating it into the topsoil. They digest the debris and excrete in their casts the nutrients they do not utilize. These casts are deposited throughout the topsoil and some even in the subsoil. So distributed through the root zone, the casts constitute a source of nutrients for vegetation. The richness of the casts depends on the kind of organic debris and mineral soil that the earthworms have for food.

Chemical analyses have been made of earthworm casts and uneaten soil. The analyses show that the casts contained about 5 times the nitrogen, 7 times the available phosphorus, 3 times the exchangeable magnesium, 11 times the potash, 1½ times the lime (calcium) that occurred in uneaten soil from the top 6 inches of a field. The increases came from the organic debris that the earthworms ate.

Some people think that earthworms free the chemicals that are in the mineral soil they eat. Actually, there is no good evidence to justify such an idea.

Earthworms conserve the nitrogen in the soil by storing it as protein in their bodies and preventing it from leaching during the winter months when vegetative growth is at a minimum. The number of earthworms in the soil tends to increase from early spring to midsummer (in Maryland) as the young worms hatch, but the total weight of the worms decreases from late spring to early fall as the mature worms die. The loss in weight represents a release of nitrogen that becomes available for the summer growth of crops.

How to Increase Earthworms in Agricultural Land

The U. S. Department of Agriculture does not recommend the artificial planting of earthworms for soil improvement although it recognizes the benefits that occur with increased numbers of earthworms in the soil. Because earthworm species have been distributed so widely, transplanted earthworms cannot be expected to survive in soil where earthworms are not already present. Species that occur normally will build up to effective population in a short time if conditions are made favorable to their development. Earthworms are sensitive to many changes in the soil, such as those brought about by cropping the land. Cropping annually to corn or soybeans usually holds the earthworm population below the minimum effective level of 10 per square foot. Winter grains and sod usually keep the population at or above the minimum effective level.

It was long thought that the only way to keep a large and active population of earthworms in tilled land was to put large amounts of manure or compost into the soil. Such treatment tends to increase the earthworm population, but it is often only partially successful. Recent investigations have provided a more efficient method of maintaining earthworms on tilled land. This new development came from studies of the life habits of earthworms.

It was found that earthworms follow a well-defined yearly cycle. One might consider the cycle as starting in the fall of the year. At that time, many of the earthworms are young, just starting their life. With the advent of wet, cool weather, they become extremely active physically. They feed on the organic debris in and on top of the soil, mix it with the mineral soil to produce casts, and make new burrows in the soil.

The high level of physical activity normally continues throughout the fall, winter, and spring. During this period, the young earthworms mature and more eggs are laid. During the winter both mature and young earthworms, as well as eggs, can be found in the soil. By late spring, most of the earthworms are mature. With the coming of summer, the soil dries and heats. The earthworms become less and less active. They lay eggs and many die. During the hottest and driest part of the summer, almost all the earthworms in a field are young ones. At that time of the year they have little effect on soil.

This cycle is a reflection of the seasonal changes in weather. Differences in weather from year to year or from one region to another can modify the cycle somewhat. It can be modified also by keeping the soil moist and cool during the summer through watering or mulching. The earthworms will then be physically active throughout the year. However, the natural life-cycle fully adapts earthworms to the seasonal changes in weather without their requiring such artificial help.

The main reason that earthworms decrease on tilled land is the lack of protective cover and organic debris in the winter. Their physical activity is at a maximum during this time, and to carry on their activity they require organic debris for food. If this is lacking, they die or leave the field in search of a more hospitable area.

In the northern section of the country, where the soil usually freezes during the winter, there is one other provision that must be made for the earthworms. They must be protected against freezing temperatures in the late fall. Earthworms' resistance to cold changes with the season. During the summer they would die if they were subjected to freezing temperature. But by winter they are fully able to live in soil that is actually frozen. Under sod or debris, then, the earthworms have sufficient time to adapt themselves to the freezing temperatures of winter, while on bare ground they may be killed before developing cold resistance.

To protect the earthworms from freezing in the late fall, almost any kind of insulation is satisfactory. Manure, chopped corn stover, wheat straw, the residue from the combining of soybeans, or a mulch of dead grass and weeds make suitable protective coverings. Such materials are at the same time a source of organic food for the earthworms over winter. In some areas a protective cover may also be obtained by seeding a cover-crop, such as ryegrass, into the tilled crop at the time of its last cultivation. Or where the crop is removed early, as corn might be when harvested for silage, a sod crop of clover or alfalfa may be sowed for winter protection.

When organic debris and (in the northern States) insulative cover are given the earthworms during the winter, they prosper even if the land is tilled every year. Soil so protected is well granulated and porous the following spring, in contrast to unprotected land.

Commercial fertilizers as ordinarily applied to soil benefit earthworms indirectly, although contact with concentrated fertilizer will kill them. Fertilizers increase vegetative residues by promoting plant growth, and so provide more food and protection for the worms. Liming is generally beneficial to earthworms because it decreases soil acidity, and promotes the productivity of the soil.

Effect on the Yield of Crops

Since earthworms improve several of the important properties of soil, it is only reasonable to expect better yields when earthworms are present. In general, this is true. A soil will usually yield more when a large earthworm population is present than when it has few earthworms. This is due in part to the effect of the earthworms themselves and in part to other productivity factors that parallel changes in the earthworm population. So the number of earthworms is frequently a useful indication of the productivity of soil.

People frequently ask how much the yield of crops is increased by earthworms. A simple, direct answer cannot be given. Earthworm activity becomes more important as the structure of the soil deteriorates, and is more desirable with some crops, like soybeans, than it is with other crops, like wheat.

The effect of earthworms on the yield of hay has been studied by the Soil Conservation Service at Beltsville, Maryland, using barrels filled with a clay loam subsoil of very poor physical quality. The same treatments were

used throughout, such as heavy fertilization, manure, lime, cultivation and seeding, except that earthworms were added to one set of the barrels. Without earthworms there was a weak growth of vegetation, mainly grass and weeds. The average yield was at the rate of 0.6 ton of hay per acre. With earthworms, there was a luxuriant growth of grass and ladino clover that yielded at the rate of 2.0 tons of hay per acre. The earthworms resulted in more than three times the yield, as well as a greater proportion of the highly desirable clover.

In soils that have good structure - high porosity and water stability - no yield benefits can be expected from the physical activity of earthworms. The benefit of earthworms is then confined to their chemical effects on soil. Where a large earthworm population exists in soil, the release of their body chemicals during the summer, when the mature earthworms die and disintegrate, must be considered.

The effect of the chemical content of earthworms on yield was determined in greenhouse tests at Beltsville, Maryland, with lima beans and millet. A silt loam soil having fairly good structure was used. To begin with, all the earthworms were taken out of the soil, which was then heavily fertilized. Dead earthworms were mixed into the soil of one set, and living earthworms were put into another set. Results were:

Earthworm treatment	Weight of crop plant	
	Lima beans (grams)	Millet (grams)
None	5.8	2.1
Dead earthworms added	16.0	2.7
Living earthworms added	16.9	3.0

Here, where the physical condition of the soil was good, the dead earthworms increased yield almost as much as the living earthworms.

Various experiments lead to the following conclusions:

(1) Earthworms help the physical condition of soil by their winter activity. With poor-structured soil and crops sensitive to structure, an increase in yield may be expected from earthworm activity; but little or no increase in yield can result if (a) the soil has good structure naturally, (b) crops grown are not especially sensitive to poor structure, and (c) growth is limited by a lack of other things, such as fertilizer or water.

(2) Earthworms help the fertility of the soil during the summer by the chemicals that are released in the bodies of the mature ones as they die. With soils of low fertility and with crops having high fertility requirements, this release may be expected to increase yields. But little or no increase in yield can result if (a) the soil is naturally rich, especially in organic matter, (b) a low-fertility crop is grown, (c) the earthworms were killed out the previous winter by improper management practices, or (d) growth is limited by a lack of other things, such as water or aeration.

Other Uses of Earthworms

In addition to their value as an agency in the improvement of the soil, earthworms furnish food for song birds in the early spring, at a time when the supply of seeds and berries is at its lowest ebb and long before insect food becomes plentiful.

Most of the various kinds of domestic poultry and their game-bird relatives feed to some extent upon earthworms. In this connection it has been shown experimentally that earthworms may swallow the eggs or larvae of the roundworm, known as the gapeworm, which is the cause of gapes in chicks, and that when chicks eat earthworms which have these gapeworm eggs or larvae in them, the chicks may contract gapes. The disease has a high mortality for young birds. Chicks are also infected by swallowing the gapeworm eggs or larvae quite apart from earthworms, but it is possible that earthworms are important as sources of infection. Recently it has been shown that turkeys constitute a normal host for gapeworms and are largely responsible for the infection of chickens, entirely independent of earthworms, where these birds are permitted to run in company.

Earthworms are advantageous in compost piles, particularly where small amounts of refuse are buried in the pile at frequent intervals. The worms feed on the fresh refuse and reduce it quickly to a composted condition. This also helps in keeping down odors. The mixing and granulation of the compost that results from worm activity also aids in producing a compost of desirable physical properties.

From time immemorial earthworms have been used by anglers as a lure for catching fresh-water fish, and they constitute the most generally available and effective bait for this purpose. The earliest published work in the English language on angling is entitled: "Fysshynge Wyth an Angle," and is said to have been written by Julia Berners, an English Benedictine nun, and was published in the Book of St. Albans in 1946. It contains explicit directions regarding the best kinds of worms for such uses and the places where they are to be sought. However, earthworms of any kind seem to find a ready market throughout the summer-resort sections, although the large rainworms or night-crawlers (Lumbricus terrestris) are most commonly used.

Destroying Earthworms in Soil

Although, generally speaking, earthworms must be regarded as beneficial organisms, they sometimes appear in places where they are not wanted. Many people object strenuously to their presence in lawns and on the putting greens of golf links. They are a nuisance in greenhouse and potting soils.

Commercial fertilizers, in the amounts ordinarily used, tend to increase rather than destroy earthworm populations. Vegetative residues are apt to be more plentiful in fertilized soil, to provide more food and protection for the worms. However, worms are sensitive to acid conditions, and acid forming fertilizer can be used to control earthworms to some extent.

The results of 3 years' application of ammonium sulphate to sod at Arlington, Virginia, for fertilizing purposes have shown that earthworms were decimated on the plots where this chemical was used. When this fertilizer is applied to soils which are naturally neutral or slightly acid in character, it creates a more acid condition that is distasteful to the worms and they disappear. Ammonium sulphate may be applied for this purpose at the rate of about 5 pounds to 1000 square feet of surface. The treatment is not recommended on calcareous soils, nor should it be applied where it is desired to retain clover in the sod, as these plants do not thrive in acid soils. It should be understood also that the ammonium sulphate acts slowly as a repellant rather than as an active poison and quick results must not be expected.

Older treatments to eliminate earthworms include the use of corrosive sublimate (bichloride of mercury) and lead arsenate. Both are violent metallic poisons and must be used with caution with respect to domestic animals, children and vegetation.

Corrosive sublimate may be applied either in water solution or mixed dry with sand or sawdust. Two, or not to exceed 3, ounces of the poison dissolved in 50 gallons of water are sufficient for 1000 square feet of green. After the solution is applied it should be followed by at least twice the quantity of water to wash it thoroughly into the soil. If it is desired to apply the corrosive sublimate dry, it should be mixed at the rate of 2 or 3 ounces to 2 cubic feet of dry sand, and the mixture scattered evenly over 1,000 square feet of green. Liberal watering should follow. When corrosive sublimate is applied in the way and at the rates suggested, especially if water is used freely afterward, no injury to the turf should result. In hot, dry times applications as suggested may cause a slight burning of the turf.

In the case of comparatively small areas of grass an ordinary sprinkling pot may be used to apply the poison solution. As corrosive sublimate rapidly corrodes metals, the solution should not be allowed to stand in a metal container, and immediate washing is advised in case a sprinkling pot is utilized for this purpose. After the application of the solution the worms usually begin to come to the surface within a very few minutes, and they should be gathered up and disposed of immediately. There is a possibility that if they are permitted to remain, some birds might be killed or injured by the poison left on the bodies of the worms.

In the case of the various varieties of bent grass, such as are favored for use on golf greens, arsenate of lead has been found safe as a vermicide, but its application to annual bluegrass (Poa annua) and crabgrass has resulted in a decided check in the growth of these grasses. As a vermicide, the arsenate of lead may be applied at the rate of 5 pounds to 1,000 square feet of surface. Uniform distribution is necessary, and may be obtained by mixing 5 pounds of the dry arsenate with about 2 cubic feet of dry sand and broadcasting the mixture evenly over the ground. The application should be made when

the grass is dry. This dose should be repeated every three or four weeks until the worms or the evidences of their presence disappear. In making new seedings of grass where worms are likely to be troublesome, the arsenate of lead should be worked into the soil to a depth of 1 or 2 inches.

The effects of organic vermicides on earthworms seem to be somewhat variable. Both chlordane and DDT will kill earthworms, but applications made for that purpose have not been consistently successful. It may be that different varieties of earthworms vary in their resistance to these poisons.

It is stated that chlordane will control earthworms in lawns for about a year. Use either 8 ounces of wettable chlordane powder (50 percent concentration) in 10 gallons of water to spray 1000 square feet of soil, or treat the same area with 5 pounds of 5 percent chlordane dust mixed thoroughly with enough sand or other bulky material to give uniform distribution with a fertilizer spreader. DDT appears to be somewhat less effective than chlordane in outside applications.

Earthworms are frequently present in potting soils, and under favorable conditions may multiply rapidly in pots and benches where their presence is undesirable for several reasons. Limewater applied freely offers a partial control and in most cases will not injure the plants. It has the advantage of being non-poisonous. About 2 cupsful of unslaked lime in a 3-gallon bucket of water, thoroughly agitated and then allowed to settle will furnish the desired clear liquid for drenching.

Chlordane and corrosive sublimate in solution as recommended for use out-of-doors may also be used. Probably some risk of burning from the latter is involved with the more tender plant varieties. Similarly, DDT has been used in some cases to control earthworms indoors. Because DDT is insoluble in water, it is most effective if dissolved first in some suitable solvent, and brought into an emulsion with water with the further addition of a wetting agent. So prepared, a concentration in solution of 0.125 percent of DDT is said to be effective in controlling the worms.

SELECTED REFERENCES FOR FURTHER READING

1. Arrhenius, O.
   1921. Influence of soil reaction on earthworms. Ecology 2, 255-7.
2. Darwin, Charles
   1882. The formation of vegetable mold through the action of worms, with observations on their habits. 326 pp., New York.
3. Eaton, Theodore H., Jr.
   1942. Earthworms of the Northeastern United States. Jour. Wash. Acad. Sci. 32, 242-9.
4. Evans, A. C. and Guild, W. J. McL.
   1947. Studies of the relationship between earthworms and soil fertility. Ann. Appl. Biol. 34, 307-30.
5. Hopp, Henry
   1947. The ecology of earthworms on crop land. Soil Sci. Soc. Amer. Proc. 12, 503-7.
6. Hopp, Henry and Slater, C. S.
   1949. The effect of earthworms on the productivity of agricultural soil. Jour. Agric. Res. 78, 325-39.
7. Lunt, M. A. and Jacobson, M. G. M.
   1944. The chemical composition of earthworm casts. Soil. Sci. 58, 367-75.
8. Olson, H. W.
   1928. The earthworms of Ohio. Ohio Biol. Survey Bul. 17, 46-90.
9. Olson, Henry W.
   1940. Earthworms of New York State. Amer. Museum Novitates 10390, 1-10.
10. Slater, Clarence S. and Hopp, Henry
   1947. Relation of fall protection to earthworm populations and soil physical conditions. Soil Sci. Soc. Amer. Proc. 12, 508-11.

APPENDIX

Earthworm Culture

Many inquiries are received on methods for raising earthworms. Consequently, a section on this topic is included. However, a warning must be given that there is no general market for earthworms for agricultural purposes. This is true for a number of reasons. Earthworms are already widely distributed. The number required to effect soil appreciably--a half million or more per acre--cannot be supplied economically by transplanting. Varieties of earthworms adapted to rapid production in commercial beds do not long survive under field or garden conditions.

Anyone interested in raising earthworms should assure himself first that he has a market before attempting their commercial production. There is a small market for earthworms as fish bait and occasionally zoological parks and educational institutions make purchases in limited quantities. In general, however, earthworm raising must be considered a hobby rather than a profitable business.

Storing and Raising Earthworms

It is better to collect the large night crawlers that are frequently preferred as bait, than it is to try raising them. In regions where they are prevalent they may be gathered on moist nights with a flashlight on almost any area of well fertilized sod. Collection in this manner is easier and more productive than digging. The light should be subdued by covering the lens with thin cloth or tissue paper as the worms instantly retreat into their burrows when a bright light is flashed upon them. The best light is one fitted with a red lens, as red light does not frighten the worms.

The common manure worm will multiply rapidly in compost heaps with but little care if precautions are taken to prevent spontaneous heating. However, a frame or box placed out-of-doors is desirable for either raising or storing worms. It should be at least 18 inches deep and of a size proportionate to the number of worms it is proposed to handle. A box 18 by 36 by 60 inches will serve very well for several hundred large worms. If the exterior of the box is well tarred it will last much longer in the soil than if untreated. Creosote is not recommended for this purpose because of its possible effect on the worm. In any case the inside of the box should not be treated with either of these substances. It may be waterproofed by painting with hot parrafin wax.

The box should be supplied with a lid to prevent flooding during heavy rains. It should be set into the soil with the upper 2 or 4 inches projecting above the surface, in a well-drained place, and should be shaded to prevent the temperature of the interior from rising too high in midsummer. A temperature of 75° F. or higher is quickly fatal to earthworms under most conditions. The box should be nearly filled with

good soil which is damp but not wet. The richer this soil is in humus the better, as the worms require less artificial feeding in rich soil than in poor. A loamy soil is preferred and a very sandy soil is not suitable.

After the box has been stocked with worms, the surface of the soil may be covered with a layer of cut sods and well decayed leaves or lawn clippings. In dry weather it will be necessary to moisten the soil in the box occasionally, but care should be taken to avoid flooding it, as too much water is injurious to the worms. Freezing kills earthworms, and in severe climates, where the soil commonly freezes to a depth of a foot or more during the winter, it may be necessary to protect the soil in the box from frost. Winter protection may be secured by giving the box a generous covering of half-decayed manure or compost.

Although under the conditions just described, earthworms can live for a long time without artificial aid, it is necessary to feed them if they are to be maintained permanently. Foods may include lawn clippings, meat and vegetable wastes, commercial rabbit food, soybean meal, or sugar in some cheap form. One dealer in earthworms claims to have been successful in feeding worms ordinary molasses spread on the surface of gunny sacking or burlap, which is simply laid upon the soil with the sticky side down and moistened occasionally. The worms will reproduce more rapidly and be more thrifty if they are well fed. When they obtain insufficient food they shrink in size and lose vigor.